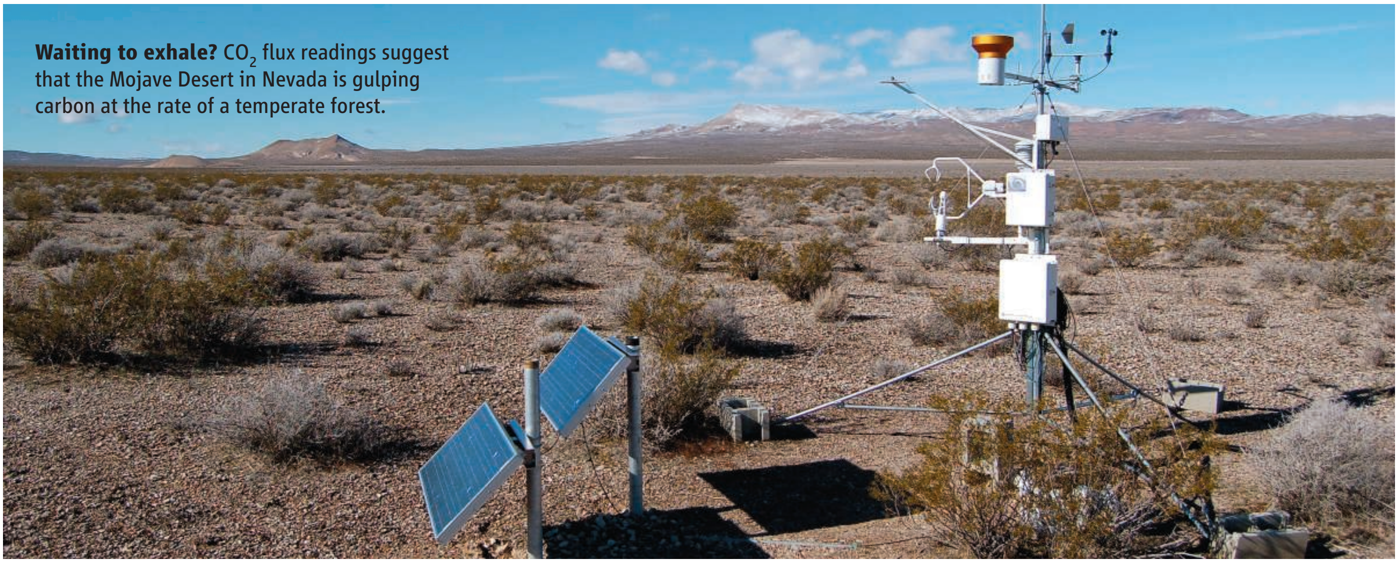

Waiting to exhale? CO_2 flux readings suggest that the Mojave Desert in Nevada is gulping carbon at the rate of a temperate forest.

ECOSYSTEMS

Have Desert Researchers Discovered A Hidden Loop in the Carbon Cycle?

URUMQI, CHINA—When Li Yan began measuring carbon dioxide (CO_2) in western China's Gubantonggut Desert in 2005, he thought his equipment had malfunctioned. Li, a plant ecophysiologist with the Chinese Academy of Sciences' Xinjiang Institute of Ecology and Geography in Urumqi, discovered that his plot was soaking up CO_2 at night. His team ruled out the sparse vegetation as the CO_2 sink. Li came to a surprising conclusion: The alkaline soil of Gubantonggut is socking away large quantities of CO_2 in an inorganic form.

A CO_2-gulping desert in a remote corner of China may not be an isolated phenomenon. Halfway around the world, researchers have found that Nevada's Mojave Desert, square meter for square meter, absorbs about the same amount of CO_2 as some temperate forests. The two sets of findings suggest that deserts are unsung players in the global carbon cycle. "Deserts are a larger sink for carbon dioxide than had previously been assumed," says Lynn Fenstermaker, a remote sensing ecologist at the Desert Research Institute (DRI) in Las Vegas, Nevada, and a co-author of a paper on the Mojave findings published online last April in *Global Change Biology*.

The effect could be huge: About 35% of Earth's land surface, or 5.2 billion hectares, is desert and semiarid ecosystems. If the Mojave readings represent an average CO_2 uptake, then deserts and semiarid regions may be absorbing up to 5.2 billion tons of carbon a year—roughly half the amount emitted globally by burning fossil fuels, says John "Jay" Arnone, an ecologist in DRI's Reno lab and a co-author of the Mojave paper. But others point out that CO_2 fluxes are notoriously difficult to measure and that it is necessary to take readings in other arid and semiarid regions to determine whether the Mojave and Gubantonggut findings are representative or anomalous.

For now, some experts doubt that the world's most barren ecosystems are the long-sought missing carbon sink. "I'd be hugely surprised if this were the missing sink. If deserts are taking up a lot of carbon, it ought to be obvious," says William Schlesinger, a biogeochemist at the Cary Institute of Ecosystem Studies in Millbrook, New York, who in the 1980s was among the first to examine carbon flux in deserts. Nevertheless, he says, both sets of findings are intriguing and "must be followed up."

Scientists have long struggled to balance Earth's carbon books. While atmospheric CO_2 levels are rising rapidly, our planet absorbs more CO_2 than can be accounted for. Researchers have searched high and low for this missing sink. It doesn't appear to be the oceans or forests—although the capacity of boreal forests to absorb CO_2 was long underestimated. Deserts might be the least likely candidate. "You would think that seemingly lifeless places must be carbon neutral, or carbon sources," says Mojave co-author Georg Wohlfahrt, an ecologist at the University of Innsbruck in Austria.

About 20 kilometers north of Urumqi, clusters of shanties are huddled next to fields of hops, cotton, and grapes. Soon after the Communist victory over the Nationalists in 1949, soldiers released from active duty were dispatched across rural China, including vast Xinjiang Province, to farm the land. At the edge of the sprawling "222" soldier farm, which is home to hundreds of families, oasis fields end where the Gubantonggut begins. The Fukang Station of Desert Ecology, which Li directs, is situated at this transition between ecosystems.

In recent years, average precipitation has increased in the Gubantonggut, and the dominant *Tamarix* shrubs are thriving. Li set out to measure the difference in CO_2 absorption between oasis and desert soil. An automated flux chamber measured CO_2 depletion a few centimeters above the soil in 24-hour intervals on select days in the growing season (from May to October) in 2005 and in 2006. The desert readings ranged from 62 to 622 grams of carbon per square meter per year. Li assumed that *Tamarix* and a biotic crust of lichen, moss, and cyanobacteria up to 5 centimeters thick are responsible for part of the uptake. To rule out an organic process in the soil, Li's team put several kilograms in a pressure steam chamber to kill off any life forms and enzymes. CO_2 absorption held steady, according to their report, posted online earlier this year in *Environmental Geology*.

"The sterilization treatment was impressive," says biogeochemist Pieter Tans, a climate change expert with the U.S. National Oceanic and Atmospheric Administration in Boulder, Colorado. "They may have found a significant effect, previously neglected, but I would like to see more evidence." Indeed, the high end of the Urumqi CO_2 flux estimates are off the charts. "That's more carbon uptake than our fastest growing southern forests. It's a ▸

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huge number. I find it extremely hard to believe," says Schlesinger, who nonetheless says the Chinese team's methodology looks sound.

At first, Li was flummoxed. Then, he says, he realized that deserts are "like a dry ocean." The pH of oceans is falling gradually as they absorb CO_2, forming carbonic acid. "I thought, 'Why wouldn't this also happen in the soil?' " Whereas the ocean has a single surface for gas exchange, Li says, soil is a porous medium with a huge reactive surface area. One question, Tans notes, is why the desert soils would remain alkaline as they absorb CO_2. Li suggests that ongoing salinization drives pH in the opposite direction, allowing for continual CO_2 absorption. But where the carbon goes—whether it is stowed largely as calcium carbonate or other salts—is unknown, Li says. Schlesinger too is stumped: "It takes a long time for carbonate to build up in the soil," he says. At the apparent rate of absorption in China, he says, "we'd be up to our ankles in carbon."

One possibility, DRI soil chemist Giles Marion speculates, is that at night, CO_2 reacts with moisture in the soil and perhaps with dew to form carbonic acid, which dissolves calcium carbonate—a reaction that warmer temperatures would drive in reverse, releasing the CO_2 again during the day. (Unlike most minerals, carbonates become more soluble at lower temperatures.) In that case, Marion says, Li's nighttime absorption would tell only half the story: "I would expect that over a year, there would be no significant increase in soil storage due to this process," he says, as the dynamic of carbon sequestration in the soil would vary from season to season. Li agrees that this scenario is plausible but notes that his daytime measurements of CO_2 flux did not negate the nighttime uptake.

Missing sink? *Tamarix* shrubs are thriving in China's Gubantonggut Desert, but the soil itself may be socking away far more CO_2 at night.

In any case, other researchers say, absorption alone cannot explain the substantial uptake in the Mojave. Wohlfahrt and his colleagues measured CO_2 flux above the loamy sands of the Nevada Test Site, where the United States once tested its nuclear arsenal. From March 2005 to February 2007, the desert biome absorbed on average roughly 100 grams of carbon per square meter per year—comparable to temperate forests and grassland ecosystems—the team reported in its *Global Change Biology* paper.

Three processes are probably involved in CO_2 absorption, Wohlfahrt says: biotic crusts, alkaline soils, and expanded shrub cover due to increased average precipitation. "We currently do not have the data to say where exactly the carbon is going," he says. Like the Urumqi team, Wohlfahrt and his colleagues observed CO_2 absorption at night that cannot be attributed to photosynthesis. "I hope we can corroborate the Chinese findings in the Mojave," he says. Arnone and others, however, believe that carbon storage in soil is minimal.

Wohlfahrt suspects biotic crusts play a key role. "People have almost completely neglected what's going on with the crusts," he says. Others are not so sure. "I'm mystified by the Mojave work. There is no way that all the CO_2 absorption observed in these studies is due to biological crusts, as there are not enough of them active long enough to account for such a large sink," says Jayne Belnap of the U.S. Geological Survey's Canyonlands Research Station in Moab, Utah. She and her colleagues have studied carbon uptake in the southern Utah desert, which has similar crust species. "We do not see any such results," she says.

Provided the surprising CO_2 sink in the deserts is not a mirage, it may yet prove ephemeral. "We don't want to say that these ecosystems will continue to gain carbon at this rate forever," Wohlfahrt says. The unexpected CO_2 absorption may be due to a recent uptick in precipitation in many deserts that has fueled a visible surge in vegetation. If average annual rainfall levels in those deserts were to abate, that could release the stored carbon and lead to a more rapid buildup of atmospheric CO_2—and possibly accelerate global warming.

–RICHARD STONE

ENVIRONMENT

U.S. Climate Change Bill Dies, But the Energy Remains

After weeks of preparation, the U.S. Senate failed to engage in a historic debate last week on how to reduce greenhouse gas emissions. But that hasn't stopped both sides from declaring victory in what amounts to a dry run for next year, under a new president and a new Congress.

Scientific and environmental groups that see such legislation as a national priority say a Democratic proposal to put a price on carbon and create a trillion-dollar market in carbon credits—which would shift money from polluters to "green" companies, governments, and the public—has at least helped frame a debate they hope to win next year. In rebuttal, Republican opponents and the Bush Administration, which promised to veto it, believe they stood up against a badly flawed bill that would have crippled economic growth and cost families thousands of dollars.

The actual cause of death for the Climate Security Act of 2008 (S.3036), ironically, was a failure by proponents to limit debate. Their inability to invoke cloture—which requires 60 votes in the 100-member body—meant that opponents would be able to postpone a vote indefinitely. That led Democratic leaders to pull the plug on 6 June. But supporters claim that the 54 senators who expressed support for moving ahead with the legislation is itself remarkable and provides a solid foundation upon which to build.

"Clearly, we knew we weren't going to get a bill this year," admits Brendan Bell, Washington representative for the Union of Concerned Scientists (UCS), which helped organize a petition signed last month by 1700 scientists and economists calling for "swift and sharp cuts" in emissions. "But in 2 years, we've gone from people denying we have a problem and saying we need to study the issue to people saying, 'Let's look

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